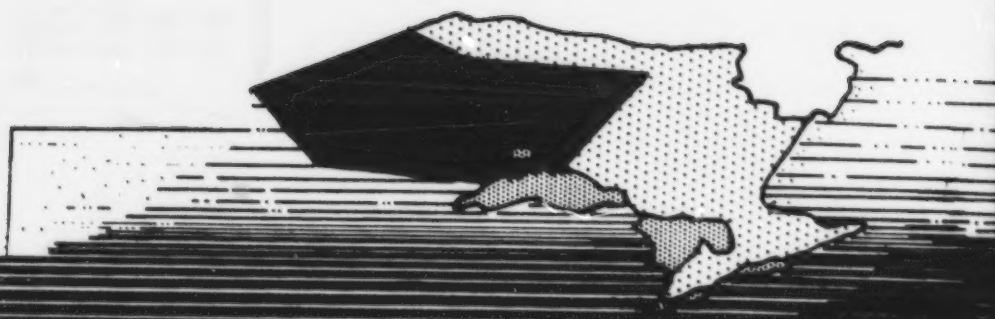




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TECHNOLOGY DEVELOPMENT UNIT**

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JACK PINE HEIGHT AND VOLUME
GROWTH RESPONSE TO AN AERIAL
RELEASE TREATMENT USING 2,4-D ON A
PLANTATION NEAR ATIKOKAN, ONTARIO

by

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ABSTRACT

Documenting herbicidal efficacy and growth response following herbicide application allows forest managers to assess various options for improving silvicultural prescriptions and application techniques. The objective of this study was to determine the resulting herbicidal and silvicultural efficacy in a 10-year-old bare root jack pine plantation which had been aerially tended using 2, 4-D at age 5 years since planting. The plantation was located on the Flanders Crown Management Unit, Atikokan, Ontario.

Destructive sampling of jack pine trees for growth layer analysis from systematic randomly-located plots on both treatment and control blocks provided the quantitative information necessary to assess growth response. The average individual tree volume on the treatment block was 43 percent greater than for jack pine growing on the control. Intermediate and open-growing jack pine responded most to release, displaying significantly greater mean tree volumes than those observed for the same classes on the control block. No significant differences in average total height between the control and treatment blocks could be established, irrespective of dominance class.

In general, the release treatment objectives were met on the Chase Lake Study area. Competing vegetation was temporarily suppressed and the conifer crop trees experienced a positive response in stem volume. Early release of jack pine, before moderate or severe suppression occurs, may be critical to optimize the benefit of the release treatment and minimize mortality. Early release of jack pine may result in a stocking and size distribution which is much more uniform and which could facilitate future management activities, improve product uniformity and future crop value.

TABLE OF CONTENTS

ABSTRACT	i
Tables	iii
Figures	iv
Acknowledgements	v
INTRODUCTION	1
METHODS	2
I. Preliminary Survey	2
II. Growth Response Study	3
Site History	3
Site Description	4
Plot Establishment - Descriptive Statistics	6
Plot Establishment - Growth Layer Analysis	7
Destructive Sampling - Growth Layer Analysis	7
RESULTS	8
I. Individual Tree Volumes	8
II. Total Height	13
III. Relative Dominance	13
IV. Competing Vegetation	13
CONCLUSIONS	17
REFERENCES	20
APPENDIX I	22
APPENDIX II	23
APPENDIX III	24

TABLES

Table 1.	Size of treatment blocks in Chase Lake Plantation	4
Table 2.	Distribution of soil depth and FEC soil types.	5
Table 3.	Average individual tree stem volumes for planted jack pine measured on the treatment and control blocks.	9
Table 4.	Descriptive statistics - average volume growth of destructively sampled jack pine from the treatment and control blocks (1982 - prior to release) stratified by dominance class.	11
Table 5.	Descriptive statistics - average volume growth of destructively sampled jack pine from the treatment and control blocks (1987 - five years following release) stratified by dominance class.	12
Table 6.	Mean percent cover of plots by competing species.	14

FIGURES

- Figure 1. The growth layer analysis sequence used in sectioning the jack pine trees for the TRIM system. 8
- Figure 2. Mean total stem volume for jack pine of the open-growing, intermediate and suppressed dominance classes in the treatment and control blocks five years after treatment (1987) from stem analysis. 10
- Figure 3. Mean total stem volume for jack pine of the open-growing, intermediate and suppressed dominance class in the treatment and control blocks for the year of treatment (1982) from stem analysis. 10
- Figure 4. Distribution of jack pine in the treatment and control blocks according to dominance class. 15
- Figure 5. Average height of competing vegetation, Chase Lake plantation. 16

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INTRODUCTION

In the early 1980's the Ontario Ministry of Natural Resources undertook a major initiative to narrow the "Regeneration Gap" between harvesting and reforestation efforts. The dollar investment in artificial regeneration, primarily in stock production and in planting effort, was increased from the pre-1980 level of approximately \$50.0 million dollars to \$200.00 million in 1989 (Goodman 1989), and the area planted or seeded was tripled (OMNR 1986). Tending thus became imperative to protect the investment, ensure plantation survival, and optimize future plantation growth and yield (Miller 1977).

To place the size of Ontario's artificial regeneration program in perspective, over 60,000 hectares were planted and another 20,000 hectares seeded on Crown Land during 1987 (OMNR 1988). Since many of these plantations will require tending due to site occupancy by non-crop vegetation, during their development, it becomes logistically infeasible to rely on only manual or mechanical methods for managing competing vegetation (Richardson 1980). Manual methods requiring the use of power saws, hand saws and blades, or mechanical methods requiring heavy equipment which tend to cause soil compaction and other physical disturbances, are often less safe and may cause greater environmental impact than that from proper herbicide treatments. In most cases, properly applied herbicide treatments are the most effective and viable method of vegetation management.

Documenting herbicidal efficacy and crop tree growth response following herbicide application allows forest managers to assess various options for improving application techniques and silvicultural prescriptions (Sutton 1985). This will, in turn, lead to the optimal use of herbicides which includes minimizing application rates and maximizing herbicidal and silvicultural efficacy.

In 1985 a literature review of studies detailing conifer response to release treatments was undertaken by the Ontario Ministry of Natural Resources - Pest Management Section. The review indicated that conifer release treatments could have a pronounced positive influence on crop tree growth rates (Dominy 1986). A subsequent in-field review of silvicultural records in Northern Ontario identified several well-documented weed control treatments older than five years old with comparable control blocks which merited further investigation for long-term growth response.

The objective of this study was to select a suitable representative jack pine plantation and to determine the resulting herbicide and silvicultural efficacy following aerial tending with 2,4-D.

METHODS

I. Preliminary Survey

Records of thirty-six candidate projects from North Central Region (Dominy 1986) were reviewed with the respective District Office staff. Selection of individual projects as candidates for further detailed study was based on quality and detail of project documentation, the absence of subsequent silvicultural treatments following the herbicide treatment and the presence of an acceptable control block (see Appendix I).

Projects which met these criteria were then subject to a field reconnaissance and screening using a more demanding set of field criteria (see Appendix II). Twenty-one projects were eventually reconnoitred in the field and seven projects were subsequently prioritized for field investigation based on the potential for further data collection (see Appendix C). Time constraints allowed for only one project to be studied during the 1987 field season; a ten-year-old

bare root jack pine plantation at Chase Lake, Flanders Crown Management Unit, Atikokan District. This plantation had been aerially tended using 2, 4-D at age 5 years.

II. Growth Response Study

Site history

The study area is located on the Flanders Crown Management Unit, Atikokan District North Central Region. The site is north of Chase Lake along the Flanders Road, latitude 48° 34', longitude 92° 13', elevation 411 metres.

The original fire-origin stand at time of harvest contained 60% jack pine, 30% trembling aspen and 10% black spruce. The vegetation type was V17 - jack pine, hardwood, shrub rich (Sims et al. 1989).

The site was harvested in 1975 and mechanically site prepared in 1976 using a wheeled skidder pulling shark-fin barrels and spiked anchor chains. The area was subsequently planted in 1977 with bare root jack pine (52%), black spruce (36%), white spruce (11%) and red pine (2%); severe mortality of the black spruce planting stock occurred following planting. The study area included a total of 36.9 hectares of plantation.

The portion of the plantation composed of planted jack pine was treated with 2,4-D low volatile ester five years following establishment to control competing vegetation. Aerial application using fixed wing aircraft was used. The rate of application was 1.7 kg/ha in a volume of 34 l/ha.

Control and treatment blocks containing similar FEC stand and soil conditions were first selected in the office using supplementary aerial photography (1:8000) prior to field establishment. Each block was further stratified to remove atypical sites such as swamps, unplanted areas and in the case of the spray block, any unsprayed zones. The areas of the respective blocks is listed in Table 1.

Table 1: Size of treatment blocks in Chase Lake plantation.

Block	Gross treatment area (ha)	Net area sampled (ha)
Treatment	18.6	10.3
Control	18.3	11.1

Site description

Soil profiles were described for (five) sample plots in each of the control and treated blocks respectively, following procedures established by Pierpoint and Uhlig (1988). The plots were established across the whole of each of the treatment and control blocks using a systematic random sampling design. The majority of soil profiles described shallow (<50 cm) to moderately deep (75 to 100 cm) soil conditions where bedrock is commonly encountered between 0 and 92 cm. (FEC Soil Type SS5 to SS8). Some areas of exposed bedrock were also present (SS1 and SS2). This range of soil conditions was common to both the control and treatment (spray) blocks. Morainial parental material predominated.

The soil moisture regime was fresh to moist dependent upon depth to lithic contact; soil drainage was moderately-well to imperfectly drained. The frequency occurrence of the various soil depths and typical FEC types are presented below (Table 2).

Table 2: Distribution of soil depth and FEC soil types

Soil Condition	Frequency occurrence (%)	
	Control	Treatment
deep (> 100 cm)	20	20
bedrock - very to moderately shallow SS1- SS3	20	40
moderately deep SS5 - SS8 (Avg. depth 50 - 75 cm)	60	40

White birch (Betula papyrifera Marsh.) and trembling aspen (Populus tremuloides Michx.) were common tree species to both blocks. Other commonly occurring tall shrubs were mountain maple (Acer spicatum Lam.), beaked hazel (Corylus cornuta Marsh.), green alder (Alnus crispa [Ait.] Pursh.) and Beb's willow (Salix bebbiana Sarg.). Common low shrubs included wild sarsaparilla (Aralia nudicaulis L.), bush honeysuckle (Diervilla lonicera L.) and low sweet blueberry (Vaccinium angustifolium Ait.). Common herbs included bunchberry (Cornus canadensis L.), yellow clintonia (Clintonia borealis [Ait.] Ras.) and large leaf aster (Aster macrophyllus L.). Bracken fern (Pteridium aquilinum [L.] Kuhn) was also common in open areas, particularly in the treatment block.

Plot establishment - descriptive statistics

An initial transect was then systematically located across the diagonal of each of the two blocks. Sample (0.0004 ha) plots were established at 20 metre intervals along each transect line. The number of sample plots required to estimate the mean stem volume (gross cubic metres) for the planted jack pine allowing a 10 percent standard error of the mean was calculated using a sequential sampling procedure. Every planted jack pine located on each of the 0.04 ha plots were measured and included in the calculations.

Additional plots were required in both the treatment and control blocks as a result of a high degree of variability in the jack pine heights and diameters. Transects within the treatment block were established at subsequent ten metre intervals parallel to the previous line in order to permit the establishment of the additional plots. Likewise, additional transects in the control block were established at 20 metre intervals from the initial transect. A total of 220 control plots and 355 treatment plots were assessed.

Height and diameter measurements at one third total height for each of the jack pine crop trees within the plots were taken. This data was then used to determine gross stem volume utilizing Forslund's formula ($\text{Volume} = 0.054156 \times \text{diameter}^2 \times \text{height}$) (Forslund 1982). The relative dominance of each crop tree was also described as being open-grown, intermediate or suppressed, and the physical condition for both the planted jack pine and competing species was recorded. The criteria for this classification were:

- Suppressed: competition within 1m radius of the crop tree is at least 30 cm taller than the crop tree and is shading the crop tree;
- Intermediate: the height of the competing vegetation within 1m radius of the crop tree is taller than the crop tree by 0 to 30 cm and is shading the spruce;
- Open-growing: the height of the competing vegetation within a 1m radius of the crop tree is less than that of the crop tree and is not shading the spruce.

In addition the number of stems of competing vegetation was tallied by (0.5m height classes for each plot), and their percent coverage for the plot was recorded.

Plot establishment - growth layer analysis

Destructive sampling of the planted jack pine for growth layer analysis occurred on each of three additional systematic - randomly located 10m x 10m plots located each of the control and treatment blocks (MacIver *et al.* 1985).

All jack pine within the plot were measured for pre- and post-treatment total heights (1982 and 1987, respectively). Diameter at breast height and the relative dominance of each tree was also recorded.

Destructive sampling - growth layer analysis

A total of 40 jack pine from each of the suppressed, intermediate and open-growing dominance classes were randomly selected from the three 10m x 10m plots located in each of the control and treatment blocks.

Individual trees were rejected for destructive sampling based on incidence of disease, damage, poor form or if a sufficient number of trees had already been selected from within the dominance class.

Detailed growth layer analysis was then conducted in Thunder Bay using the Tree Ring Increment Measuring System (TRIM). Each destructively sampled jack pine was sectioned along the bole; discs were collected according to a pre-determined sampling sequence (Figure 1). Ring widths on each section of known height were measured for two pre-determined radii (north and south) and an average ring width sequence was calculated. The tracking accuracy of the TRIM system was 0.01mm.

0cm
40
70
100
130
150
175
200
.
.
.
every 25 cm
to the top

Figure 1: The growth layer analysis sequence used in sectioning the jack pine trees for the TRIM system.

RESULTS

I Individual Tree Volumes

The average individual stem volume for jack pine measured in the treatment block was 43 percent greater than for jack pine growing on control block (Table 3).

Table 3: Mean individual stem volumes for planted jack pine on the treatment and control blocks.

Block	Sample size (n)	Average stem volume (d m ³)	Standard error of the mean (d m ³)
Treatment	309	60.00 <u>a</u>	± 5.13
Control	252	41.90 <u>b</u>	± 3.35

Treatment response variables followed by different letters differ significantly at the $p=0.01$ level.

The mean 1987 total stem volume for the open-growing and intermediate jack pine on the treatment block were significantly greater than that for jack pine within the same dominance classes growing on the control block. (Figure 2).

In contrast, suppressed jack pine measured on the treatment block displayed a smaller but not significantly different average total stem volume than those sampled on the control block.

Given that there were no significant differences in mean total stem volume for the jack pine, based upon stem analysis data, in all but the suppressed dominance class prior to treatment in 1982 (Figure 3) (Table 4), it would suggest that the release benefited open and intermediate trees (Table 5). Five years after the release treatment, jack pine sampled from each of the three dominance classes in the treatment displayed significantly greater current annual volume increments (C.A.I.) and total cumulative volumes than those in the control. The impact of releasing the planted jack pine from competing vegetation is also evident by greater mean annual increments for open-growing trees.

Table 4: Descriptive statistics - average volume growth for destructively sampled jack pine from the treatment and control blocks (1982 - prior to release) stratified by dominance class.

Dominance class		Sample size	Total cumulative volume (dm ³)	Mean annual volume increment (M.A.I.) (dm ³)	Current annual volume increment (C.A.I.) (dm ³)	Mean cumulative volume increment (dm ³)
Open-growing	-Control	48	45.3 <u>a</u>	0.15 <u>a</u>	0.46 <u>a</u>	0.94 <u>a</u>
	-Treatment	38	41.8 <u>a</u>	0.17 <u>a</u>	0.57 <u>a</u>	1.10 <u>a</u>
Intermediate	-Control	35	26.5 <u>a</u>	0.12 <u>a</u>	0.37 <u>a</u>	0.75 <u>a</u>
	-Treatment	36	28.4 <u>a</u>	0.12 <u>a</u>	0.32 <u>a</u>	0.78 <u>a</u>
Suppressed	-Control	43	22.9 <u>a</u>	0.05 <u>a</u>	0.26 <u>a</u>	0.11 <u>a</u>
	-Treatment	38	12.9 <u>b</u>	0.05 <u>a</u>	0.16 <u>b</u>	0.33 <u>b</u>

NOTE: Treatment response variables followed by different letters differ significantly at the p=0.01 level within a dominance class.

Table 5: Descriptive statistics - average volume growth for destructively sampled jack pine from the treatment and control blocks (1987-five years following release) stratified by dominance class.

Dominance class	Sample size	Total cumulative volume (dm ³)	Mean annual volume increment (M.A.I.) (dm ³)	Current annual volume increment (C.A.I.) (dm ³)	Mean cumulative volume increment (dm ³)
Open-growing	48	279.2 a	0.52 a	1.19 a	5.81 a
	38	336.3 b	0.79 b	2.56 b	8.84 b
Intermediate	35	149.8 a	0.38 a	0.81 a	4.27 a
	36	211.8 b	0.53 a	1.77 b	5.88 a
Suppressed	43	144.3 a	0.31 a	0.28 a	3.35 a
	38	97.0 b	0.24 a	0.72 b	2.67 a

NOTE: Treatment response variables followed by different letters differ significantly at the p=0.01 level within a dominance class.

II Total Height

No statistically significant difference was found between the mean heights of the jack pine sampled from the treatment and control blocks, irrespective of dominance class. The average height for jack pine sampled in the control block was 3.94 m compared to 3.87 m for pine on the treatment block.

III. Relative Dominance

There were a greater number of open-growing and suppressed jack pine trees within the control block as compared to the treatment based upon the initial plot descriptions.

There were only slightly fewer intermediate class trees in the control than in the treatment block (Figure 4).

IV. Competing Vegetation

The average height of each of the principal competing species was less on the treatment block five years after the aerial release treatment with 2, 4-D, than that observed for the same species on the control (Figure 5). The major competing species on the site were trembling aspen, white birch, mountain maple, beaked hazel, speckled alder, and willow.

The mean percent cover for the same principal competing species was also less on the treatment plots compared to the plots in the control, excepting mountain maple and trembling aspen (Table 6).

Table 6: Mean percent cover of plots by competing species.

Block	Trembling aspen	White birch	Mountain maple	Beaked hazel	Green alder	Beb's willow
Treatment	2.5	0.6	5.3	1.7	0.6	1.5
Control	2.2	4.7	4.2	8.5	4.4	2.2

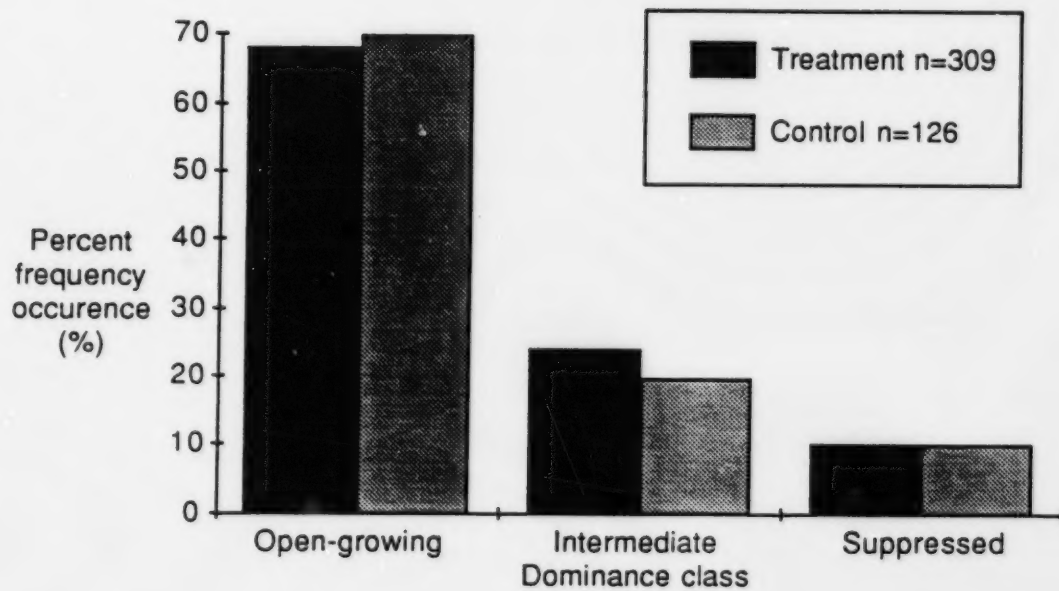


Figure 4: Distribution of jack pine in the treatment and control blocks according to dominance class.

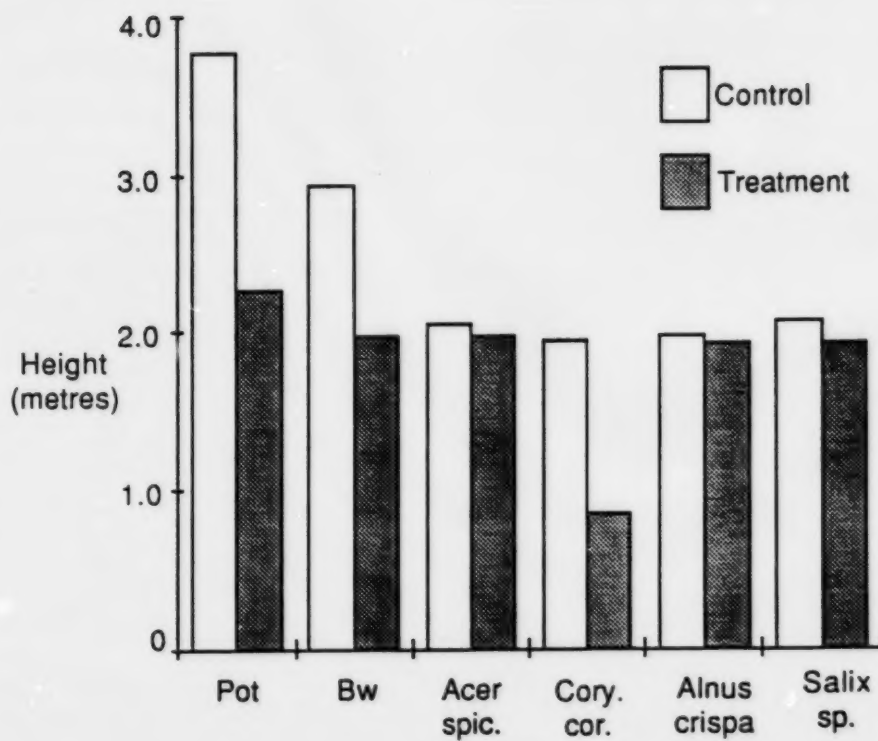


Figure 5: Average height of competing vegetation, Chase Lake plantation.

DISCUSSION AND CONCLUSIONS

Vegetation control is an important part of jack pine management because competition can greatly reduce the survival, growth and development of this species. Studies in the U.S. Northeast and Lake states have shown that dense thickets of naturally regenerating trembling aspen and paper birch will preclude the establishment and development of jack pine on former conifer sites (Walstad and Kuch 1987). The critical relationship of conifer yield versus the amount of hardwood present in a stand will determine the importance of the competition on the site. This relationship has been studied in greatest detail using loblolly pine (Pinus taeda L.) in the southern states. Pine yield appears to be negatively related to the relative proportion of hardwood basal area in the stand irrespective of other site and stand effects (Walstad and Kuch 1987).

Individual jack pine follow a rather steep sigmoidal growth curve characteristic of intolerant species, when grown in the absence of competition (Walstad and Kuch 1987). In the seedling stage jack pine may be relatively more tolerant to competition (Fowells 1965). Intermediate and suppressed pine will often maintain height growth and may even increase height growth under moderate levels of competition. However, this usually occurs at the expense of crown development, root expansion, and diameter growth (Walstad and Kuch 1987). Height growth in living intermediate or suppressed jack pine will usually not be significantly different from that of open-growing trees. This is because the annual height of suppressed intolerant conifer species must at least equal the height growth of any associated competing vegetation (including open-growing jack pine) if they are to continue to survive and not be overtopped (Walstad and Kuch 1987).

The premise that height growth may continue or even increase under moderate competition appears to be illustrated in the study at Chase Lake. The average height of jack pine in the control block was slightly greater than those sampled in the treatment block. A large portion of the jack pine growing in the control block were growing under moderate competition.

It is interesting to note that the mean stem volumes for the same jack pine, were significantly greater for those in the treatment block as compared to those on the control. If height growth had been the only growth parameter measured the true effect of the release treatment on stem volume would not have been determined.

An objective of a release treatment is to temporarily suppress competing vegetation to allow the crop trees to reach Free-to-Grow status (OMNR 1986). Five years after the 2, 4-D release treatment at Chase Lake, herbicidal efficacy on the treatment block was still evident (*sensu* Sutton 1985). The species composition had not changed in that the same competing species were still present on both the treatment and control blocks. However, the average height of most of the competing species was less on the treatment area.

In general, the release treatment objectives were met on the Chase Lake study area. Competing vegetation was temporarily suppressed and the conifer crop trees experienced a positive response in stem volume growth. However, there are also some contradictions in the study results. Average stem volume for jack pine (post-treatment) was greater on the treatment block while average height was lower. There were also more open-growing jack pine on the control block, but the competing vegetation was taller and jack pine stem volume was lower. These results may be attributable to the growing condition of the jack pine prior to release.

Normally jack pine growing under moderate to heavy competitive pressure have sparse crowns, spindly stems and shade-adapted needles which are susceptible to sun damage when suddenly exposed to open growing conditions. Therefore, early release of jack pine, before moderate or severe suppression occurs, may be critical to optimize the benefit of the release treatment and minimize mortality

Early release of jack pine prior to mortality or suppression may result in a stocking and size distribution which is much more uniform and which could facilitate future management activities and improve product uniformity and value at harvest (Willcocks, Bell and Williams 1989).

Significant gains in total cumulative volume and current annual volume increment have been realized on the jack pine trees growing on the treatment block. These gains in individual tree growth coupled with the ensured survival of the existing growing stock should affect future merchantable volumes on a per hectare basis. Increased volume increments on an individual tree basis should result in the stand reaching its culmination of maximum mean annual increment in shorter time, thus contributing to a potential reduction in rotation age. Increased stocking to open-growing and intermediate trees after release treatments should also ensure that volume is not lost in mortality of intermediate and suppressed jack pine and that the total available growing space of the site is utilized to advantage in maximizing volume production.

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APPENDIX I

Criteria for Selection of Candidate Study Areas

- a. Weed control treatments must be at least five years old.
- b. Projects must be well documented re: location, regeneration treatment, weed control treatment.
- c. There must be no subsequent silvicultural treatments which could compromise the ability to assess the success of the weed control treatment.
- d. Each project must have a control area within or adjacent to the treated area which may be assessed to compare treated versus untreated growth response.

APPENDIX II

Secondary Field Criteria for Selecting Study Areas

- a) Can the project be located?
- b) Can the boundaries of the treated and untreated blocks be located or defined with certainty?
- c) Is there a distinct difference in the size or species composition of non-crop vegetation in the treated vs. the untreated block?
- d) Is the site (soil, moisture regime, topography, etc.) the same on both treated and untreated blocks?
- e) Is the site uniform? If it is not, is there the same proportion of each of the different site types on the treated and untreated blocks?
- f) Is the mechanical site preparation, if any, identical on both treated and untreated blocks? This should be verified by on-site inspection.
- g) Are there crop trees on the untreated as well as the treated blocks?
- h) Were the same species and stock type planted in the treated and untreated blocks?
- i) Were the untreated and treated blocks planted at the same time and at the same spacing?
- j) Are there apparent differences in crop tree stocking and height in the treated vs untreated blocks, based on ocular assessment?
- k) Is there any indication that both the treated and untreated blocks may have been sprayed at some time either before or after the spraying indicated in the records?

APPENDIX III

Long Term Conifer Benefit To Vegetation Management
North Central Region Project Review

Project Priority List

<u>District</u>	<u>Basemap #</u>	<u>Tending Project</u>	<u>Method Of Applic.</u>	<u>Priority</u>
Atikokan	485921	31(82)	Aerial	1
Terrace Bay	492854	23(83)	Aerial	2
Terrace Bay	492854	16(79)	Ground	3
Atikokan	486911	23(75)	Aerial	4
Geraldton	498871	36(80)	Aerial	5
Terrace Bay	495853	22(78)	Ground	6
Atikokan	487912	32a(79)	Aerial	7